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(54) Title of Device: PAPER-MAKING FELT AND ITS PRODUCTION METHOD

(57) Claim

Claim 1 A felt for the production of paper comprises a base layer and a surface layer formed on at least one surface of the base layer, and the base layer and the surface layer are unified by needling; the surface layer contains divided fine fibers which are sepa-

rated by needling, and non-dividing fibers; before separating the dividing fibers the dividing fibers are compounded with the non-dividing fibers in a ratio of 40-90wt % of the total amount of the dividing fibers and the non-dividing fibers.

Claim 2 A felt for the production of paper in which the dividing fibers are circular in cross section and have a fineness of 4-20 deniers, and in which the material composing the dividing fiber is an eight-petal shape, and the cross-sectional shape of the other material is a fan shape divided into eight segments.

Claim 3 A felt for the production of paper of Claims 1 and 2 in which the surface layer has a thickness of 0.35-1.2mm,

Claim 4 A felt for the production of paper of Claims 1–3 in which the surface layer has an air permeability of 10-30cm^3/ sec/cm^2.

Claim 5 A manufacturing method for the production of paper-making felt in which a base layer, on at least one surface of which is disposed a divided fiber pad layer comprised of 40–90wt% dividing fibers and the remainder of non-dividing fibers, and not only the divided pad fiber layer (I), but the interface part (II) between the divided pad fiber layer and the base layer as well are superimposed and pierced and needled so that, while the dividing fibers divide, [the divided pad fiber layer (I) and the interface part (II)] are joined by the fibers which are caught by the needle barbs and carried upward.

Claim 6 A manufacturing method for the production of paper-making felt of Claim 5 in which the dividing fibers are comprised of material which is circular in cross section and have a fineness of 4-20 deniers, and in which the material composing the divided fiber is an eight-petal shape, and the cross-sectional shape of the other material is a fan shape divided into eight segments.

Detailed Description of the Invention

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Industrial Field of Application This invention relates to paper-making felts used in the production of paper and to a manufacturing method for these felts. More specifically, it relates to paper-making felts used in the production of high-quality paper and to a manu-

facturing method for these felts.

0002

Prior Art

Paper-making felts need to have the ability to act as a conveyor for wet paper, to wring water from the wet paper and, at the same time, to smooth the surface of the wet paper. High-quality papers and onion skin papers and other papers in particular demand felts which are capable of bringing out their properties by creating a surface without unevenness. There is a demand for felts that will produce paper with greater surface fineness and smoothness, and for paper-making felts which make use of finer fibers.

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Problem Which the Invention Seeks to Resolve

However, the fibers tend to adhere to the cylinders during carding when fine fibers are used, and the material becomes film-like and is hard to peel off. Also, the method is defective in that in the needling process, due to there being too great a difference between the size of the needles and the size of the fibers, the material assumes a wavy shape and is no longer flat. Even if these difficulties are overcome and a paper-making felt is made of extremely fine fibers, new problems arise such as that these extremely fine fibers are likely to tear, or there can be a depilation problem [fibers falling out]. Moreover, while it is true that the thinner the fibers used, the finer and smoother the paper produced, by the same token, the felt's ability to drain water decreases, thereby sacrificing a vital property of paper-making felt, that of being able to wring the wet paper.

0004 This invention overcomes the above-described defects. Its purpose is to present a paper-making felt and a method for its manufacture that maintains its permeability without the problem of depilation which produces paper with a fine, smooth surface.

Means of Solving the Problems

0005 The first invention of the paper-making felt comprises a base layer and a surface layer formed on at least one surface of the base layer, and the base layer and the surface layer are unified by needling; the surface layer contains divided fine fibers which are separated by needling, and non-dividing fibers; before separating the divided fine fibers the dividing fibers are compounded with the non-dividing fibers in a ratio of 40-90wt.% (here-

inafter abbreviated as "%") of the total amount of the divided fine fibers and the non-dividing fibers.

0006 Here, the "base layer" means the fiber layer comprising a base fabric and a typical fibrous pad layer. The "dividing fibers" means the composite fibers having the structure which divides the fibers into divided fine fibers by means of needling. A variety of properties, cross sectional shapes, diameters, and methods of divided are acceptable. For example, the dividing fibers can have the circular shape indicated in Invention 2, with a fineness of 4–20 deniers, and where the material composing the divided fiber is an eight-petal shape, and the cross-sectional shape of the other material is a fan shape divided into eight segments. The paper-making felt of this invention offers excellent results when fibers with a fineness of 4–20 deniers are used. In other words, it is difficult to do needling if the dividing fibers are too thick, and it is impossible to obtain divided fine fibers. On the other hand, if the dividing fibers are too thin, then the dividing fibers are apt to tear, and depilation becomes a problem.

0007 With these dividing fibers provided at a ratio of 40–90%, excellent surface smoothness is obtained without a decrease in air permeability (water porosity). At a ratio exceeding 90%, there are too many fine fibers, the felt is apt to adhere to the cylinders during carding, and it becomes difficult to handle. "Divided fine fibers" means the dividing fibers which are mechanically peeled by needling and which diameter is made finer by multiple divisions. "Non-dividing fibers" means typically normal fibers which are not divided by needling.

0008 The paper-making felt of this invention is not limited to the surface layer thicknesses described above, but it is preferable for them to be 0.35–1.2mm, as shown in Fig. 3. There is little increase in smoothness if the fibers are less than 0.2mm in thickness, and there is a tendency for peeling to take place in the layers if the fibers are greater than 1.2mm in thickness. Further, if it is too fine, there is a decline in permeability. The air permeability of the paper-making felt of this invention is preferably 10-30cm^3/ sec/cm^2. This [degree of permeability] permits the paper-making felt to maintain its water draining ability when it is being wrung between the press rolls, while suppressing the re-wetting phenomenon that occurs when the water which has been squeezed off of the wet paper fall back from the felt onto the paper.

0009 In the method of manufacturing the 5th invention of this paper-making felt which is characterized by a base layer, on at least one surface of which is disposed a divided fiber pad layer comprised of 40–90wt% dividing fibers and the remainder of non-dividing fibers, and not only the divided pad fiber layer (I), but the interface part (II) between the divided pad fiber layer and the base layer as well are superimposed and pierced and needled so that, while the dividing fibers divide, [the divided pad fiber layer (I) and the interface part (II)] are joined by the fibers which are caught by the needle barbs and carried upward, a variety of dividing fibers can be selected and used as above. For example, as in the 6th invention, the dividing fibers can have a fineness of 4-20 deniers, and the material composing the divided fiber can be an eight-petal shape, and the cross-sectional shape of the other material can be a fan shape divided into eight segments.

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Operation of the Invention

In the paper-making felt and method of its manufacture of this invention, a divided pad felt layer consisting of dividing fibers and non-dividing fibers is disposed upon a base material, and the base material and pad felt layer are unified by needling. During the process of forming the base layer and the surface layer, the dividing fibers are divided and gradually become extremely thin divided fine fibers. Thus, a felt is obtained which does not become wavy as it would if extremely fine fibers were used at the outset, since the surface of the felt is fine, and this fineness serves to increase paper quality because of the felt's flatness. Moreover, water wringing capacity is maintained since the surface layer is formed thinly on a base layer which has water permeability and wringing ability. At the same time, re-wetting of the paper is prevented by the finely-formed surface layer which keeps the water that has passed through the surface layer from flowing back onto the paper sheet. Further, since the dividing fibers are needled, depilation of the divided fine fibers, which would likely occur if extremely fine fibers were used from the beginning, is unlikely since the fibers are separated but remain gathered together in bundles.

0011 Preferred Embodiments

The present invention will be explained specifically according to the following preferred embodiments.

(1) Preferred Embodiment 1

① Manufacturing method for a paper-making felt

First, preparations are made for the production of a base fabric intertwined and unitized with upper and lower pad fiber layers. This takes the form of a conventional paper-making felt made by needling. The warp of the base fabric consists of 2 strands of 0.20mm-diameter polyamide monofilament which are twisted together along with another 3 strands twisted together (thread count of 8 threads/cm), while the woof consists of 0.33mm polyamide monofilament (thread count of 6 threads/cm). These are woven together in a single weave on a flat weave.

0012 A dividing-type pad fiber layer consisting of 80% dividing fibers and 20% non-dividing fibers is placed on top of this base fabric. Daiwabo's composite dividing fiber "Seba" (product number DFS-5) was used for the dividing fibers. These dividing fibers 21 have the circular cross section shown in Fig 2, and comprise an eight-petal shape petal area 211 (including a core area 211a. The composition is polyamide.); and the remaining area 212 is an eight-segment fan-shaped area (composed of polyester). The thread fineness is 8 deniers. These dividing fibers 21 are divided by needling into the fine fiber cross sections of each petal area 211 and remaining area 212. The non-dividing fibers 23 do not have the characteristics of the dividing fibers 21; they are ordinary fibers used in conventional paper-making felts. Dupont's nylon, 6 denier was used here. The types and properties of the fibers used in the pad fibers layer, the dividing fibers, and the non-dividing fibers can be freely varied according to the goals for the products produced.

0013 Next, the dividing-type pad fiber layer is superimposed on the base fabric and pierced by needling. The dividing-type pad fiber layer and the ordinary pad fiber layer are caught by the barbs and their fibers are moved down in order to join [the layers]. At the same time, needling divides the dividing fibers in the dividing-type pad fiber layer to produce divided fine fibers. The needling depth is shallow with a large number of needles in this needling step. This is so that although the division of the dividing fibers is promoted, damage to the ordinary pad fiber layer which is below the dividing-type pad fiber layer, and to the base fabric itself, is limited. Specifically, needle depth was 12mm (normally 16mm), with 650 needles/cm^2 (ordinarily 350 needles/cm^2). Relative slender #36 needles were used. There were 3 barbs on each of the needles' three edges for a total of 9 barbs [per needle]. The barbs projected relatively slightly from the needle edges in order to

separate the dividing fibers in the surface layer thoroughly.

0014 As needling progresses, the thick dividing fibers are mechanically separated, the dividing fibers within the dividing-type pad fiber layer are converted into extremely fine fiber dividing fibers, and a felt which has a base layer 1 and surface layer 2 which is intertwined and unitized with it is produced, as shown in Fig. 1. Since the dividing fibers 21 maintain their thick shape in the initial stage of needling, they are elastic and, in contrast to the use of extremely fine fibers from the outset, there is no surface waviness created. Thus, the fibers have elasticity and do not form depressions, and as the needles penetrate them the thick cross-sections of the fibers become finer. In this way, the defects that characterize the prior art manufacturing process can be avoided, and a surface layer 2 with the desired divided fine fibers 22 is formed.

0015 ② Constitution of the paper-making felt

The total measured thickness of this paper-making felt is 3.82mm. The thickness of its surface layer is approximately 0.5mm. The overall weight [*metsuke*] is 1150 g/m^2, with a density of approximately 0.301 g/cm^3. An ordinary pad fiber layer 12 (weight 600 g/m^2) is disposed on the upper surface of the comparatively rough weave (weight 250 g/m^2) of the base fabric 11 of the base layer 1. Similarly, there is a pad fiber layer 13 (weight 100 g/m^2) on the lower surface of the base fabric 11. These are unitized by needling. The surface layer 2 is a nonwoven fabric, comprising divided fine fibers 22 (which are divided), and non-dividing fibers 23 (which never had the ability to be divided).

0016 The divided fine fibers 22 are extremely fine fibers which in the needling step are unitized with the base layer 1 and the surface layer 2, and comprises a part of the surface layer 2 which is divided fibers of the dividing fibers 21. Each strand of dividing fibers 21 comprise 9 units of eight-petal shape petal areas 211, and the remaining areas 212 comprise 8 units. Since they are divided, these are comprised of fibers that are approximately 1/17th the thickness of the original dividing fibers 21. In contrast with conventional extremely fine fibers in which each of the fibers is arranged in a disorderly way, these divided fine fibers 22 are to some extent bundled as shown in Fig. 3.

0017 (2) Preferred Embodiments 2 and 3, and Comparative Example

Preferred Embodiment 2 has a surface layer 2 with a dividing-type pad fiber layer

23 comprising a 50%–50% combination of dividing fibers 21 and non-dividing fibers 23. The overall weight is 1194 g/m^2, the thickness is 4.02mm, and the density is 0.297 g/cm^3. Otherwise it has the same specifications as Preferred Embodiment 1. Preferred Embodiment 3 has a surface layer 2 with a dividing-type pad fiber layer 23 comprised of 30% dividing fibers 21 and 70% non-dividing fibers 22. The overall weight is 1182 g/m^2, the thickness is 4.21mm, and the density is 0.286 g/cm^3. Otherwise it has the same specifications as Preferred Embodiment 1. A comparative example consists of surface layers which is 100% non-dividing fibers. The overall weight is 1145 g/m^2, the thickness is 4.21mm, and the density is 0.272 g/cm^3. Otherwise it has the same specifications as Preferred Embodiment 1.

0018 (3) Evaluation

The following is an evaluation of the paper-making felt of this invention.

Fig. 4 shows a cross sectional view of Preferred Embodiment 1 of the paper-making felt of this invention (8-denier dividing fibers 21 are needled to separate them 30–40%) (magnification 15 times). Fig. 5 shows a paper-making felt (comparative example), comprised of the same 8-denier dividing fibers 21 forming a surface layer 2 (magnification 15 times). We were able to observe the separation of the dividing fibers 21, their conversion to divided fine fibers 22, and the formation of a thin surface layer 2 (near the top of Fig. 4). Fig. 6 shows the surface situation of the surface layer 2 of Preferred Embodiment 1. Fig .7 shows as a comparative example a constitution with non-dividing fibers 23 of the same 8-denier thickness as the dividing fibers 21. In Fig. 6, the divided fine fibers 22 which have been separated to become finer are evenly distributed in the surface layer 2. As can be seen in Figs. 4–7, it was confirmed that only the thin surface layer of the paper-making felt of this invention is finely-textured and has increased smoothness.

0019 Fig. 8 is an enlarged photograph (125 times) of the surface layer 2 of Preferred Embodiment 1. Fig. 9 is an enlarged photograph (125) times of a Comparative Example which has ordinary fibers of the same 8-denier thickness as the dividing fibers 21. As shown in Fig. 8, the paper-making felt of this invention has divided fine fibers 22 made from the dividing fibers 21 which, in contrast with conventional extremely fine fibers in which each of the fibers is arranged in a disorderly way, these divided fine fibers 22 are to some extent maintain a bundled arrangement. Further, it was seen that the divided fine fibers 22 comprise the fine-textured surface layer 2. There are also dividing fibers which

are not divided to be found here and there.

0020 ② Wear Properties

The use of fine fibers in the surface of a paper-making felt tends to be a negative factor in terms of roll wear. [The inventors] examined felts blended with as much as 80% dividing fibers 21 under the following parameters and found that the amount of wear increased by about 10% and then stopped.

Test parameters:

Paper-making speed	820 m/minute
Press load	92 kg/cm (loading per surface length of 1cm = linear pressure)
Water shower pressure	1.6 kg/cm^2

When the paper-making felt [of this invention] was used under these parameters, there was hardly any fiber breakage or depilation or other problems.

0021 ③ Water Permeability

[The inventors] investigated the water permeability of Preferred Embodiments 1, 2, and 3, as well as that of the Comparative Example containing 100% non-dividing fibers. This test conforms to JIS-1096, and was conducted using a Frazier Air Permeability Instrument. Results are shown in Fig. 10. Heat set and finished samples after the needling operation was performed are indicated in the table with an "X", and shows permeability prior to being pressed. The "O" indicates measurements taken of samples which have been needled and heat set finished after 56 hours running time while under a load of 62 kg/cm and water-showered. Water permeability and air permeability are interrelated. A low level of air permeability indicates that it will be difficult for water from the wet paper to pass through the paper-making felt.

0022 Air permeability results are shown in Fig. 10. Although air permeability decreases along with the increase in the proportion of dividing fibers 21, satisfactory results were obtained at a ratio of 80% dividing fibers 21. Various studies [conducted by the inventors] suggest that, in practice, there would be no problems in going up to a level of 90%. Air permeability of 10–30 cm^3/second/cm^2 can be maintained up to 90%, thus maintaining the wet paper water-wringing capacity required of a paper-making felt. The surface layer thickness in these tests was 0.5–0.6mm. Given the fine-textured surface layer's thin struc-

ture, there is little flow resistance .

0023 ④ Surface Properties

[The inventors] investigated the surface flatness of the paper-making felt of this invention. The surface flatness of a variety of combinations of dividing fibers 21 and non-dividing fibers 23 comprising the divided pad fiber layer 2' was evaluated. The evaluations were performed with Kawabata's Evaluation System-4 Surface Tester, Kato Iron Works, Co., Ltd., Kyoto Japan. The friction coefficient of the surface of the paper-making felt itself was investigated and the surface characteristics (smoothness) were evaluated. Fig. 11 shows a schematic diagram of the friction test apparatus. In the test, the paper-making felt A is placed beneath and brought into contact with abraders 6 (stainless steel staples with each set of pins arranged in stick fashion prior to use [as in a stapler]). 50g of weight was applied to the pins 6 (the weight adjusting area 5 accommodates 5 gram weights). The paper-making felt was then moved left and right in order to find the wear coefficient. 7 in the figure indicates the measuring part. Fig. 12 shows the wear coefficients of a product produced according to Preferred Embodiment 1 (in which the divided fiber ratio is 80%). Fig. 13 shows the wear coefficient for the Comparative Example, which is 100% non-dividing fibers.

0024 The wear coefficient and its change of the dividing fibers were both 80%, but there was only slight waviness, little surface bumpiness, and surface quality was maintained. A hand contact test suggested that the surface layer remained smooth even when the distribution of the dividing fibers 21 in the divided pad fiber layer was 30%, 50%, or as high as 80%.

0025 (4) Effect of the Preferred Embodiments

In the preferred embodiments of the paper-making felt of the present invention, divided fine fibers 22 are converted by needling the dividing fibers 21 which are contained only in the surface layer. Therefore, felt surface smoothness is enhanced while maintaining water permeability, thereby improving paper formation. The fine texture of the surface prevents rewetting of the paper sheet due to backflow of the water which has been wrung from the wet paper by the felt when the felt and paper separate from the press area, thereby greatly the amount of drying steam needed in the dryer part.

0026 In the needling step, since the dividing fibers 21 are divided to form the divided fine fibers 22 of the surface layer without the problems of waviness or adhesion of extremely fine fibers to the cylinders during carding when extremely fine fibers are used from the outset. Production is able to proceed easily to obtain a paper-making felt with a smooth surface. Moreover, since the divided fine fibers 22 which are produced when the dividing fibers 21 are divided and which comprise the surface layer are not completely randomly arranged, but tend to maintain a bundled configuration, the kind of depilation characteristic of paper-making felts in which extremely fine fibers are used from the beginning is not in evidence. Further, there is absolutely no balling up [pilling] of the felt of the kind seen when extremely fine fibers which are used from the start of felt production break and bunch up, so felt quality can be maintained.

0027 A number of variations of this invention can be made within the scope of the invention according to its goals and applications. Thus, the materials used for the base fabric 11, the pad fiber layers 12, 13, the dividing fibers 21, and the non-dividing fibers 22 can be selected as needed depending on the purpose and application. For example, polyester thread can be used for the base fabric 11 as suitable for the application. Thread thickness and twisting methods can be changed, with diameters of 0.1–0.3mm, or monofilaments can be used with diameters of 0.25–0.5mm. Here, the thicker the threads, the smaller the thread count. The weave need not be limited to a flat weave; a 1/3 collapsed weave [*unknown term: "kuzushi ori"*] is also acceptable. Further, the base fabric of this invention also permits double and triple weaves, and is not limited to a single weave. Also, good results can be obtained with non-dividing fibers 23 of 4–20 deniers' fineness.

0028 Moreover, the surface [of the felt] can be further enhanced by increasing the separation rate of the divided fine fibers by needling. However, this can lead to breaking of the constituent fibers and to too-great a [fiber] density, among other problems, so it is desirable to maintain a balanced degree of separation. Apart from the thicknesses suggested above, favorable results can be obtained from surface thickness within the range of 0.35–1.2mm. Thicknesses under 0.35mm can lead to unevenness, even if divided fine fibers are produced, while thicknesses of over 1.2mm can create too much flow resistance in the paper-making felt, leading to reduced water permeability.

0029 Effect of the Invention

As described above, the present invention offers a paper-making felt with a flat surface that enhances paper quality while preserving the important characteristics of water permeability. Further, the paper-making felt of the invention has little fiber breakage or depilation.

Brief Description of the Drawings

Fig. 1 Explanatory cross-sectional view of Preferred Embodiment 1 of a paper-making felt

Fig. 2 Side cross section of the dividing fiber used in Preferred Embodiment 1

Fig. 3 Explanatory drawing of the divided fine fibers in the surface of Preferred Embodiment 1

Fig. 4 Photograph showing the fibers of the paper-making felt of Preferred Embodiment 1 in cross section

Fig. 5 Photographic cross section showing the fibers of paper-making felt which does not incorporate dividing fibers in cross section

Fig. 6 Photograph showing the fibers in the surface of Preferred Embodiment 1

Fig. 7 Photograph of the fibers of a surface of a felt which does not incorporate dividing fibers

Fig. 8 Close up photograph of the fibers shown in Fig. 6

Fig. 9 Close up photograph of the fibers shown in Fig. 7

Fig. 10 Graph showing the relationship between air permeability and the distribution of dividing fibers in the divided fiber pad layer

Fig. 11 Schematic drawing of the surface tester used to test surface properties

Fig. 12 Graph showing the friction coefficient of the surface of Preferred Embodiment 1.

Fig. 13 Graph showing the friction coefficient of the surface of a paper-making felt which does not incorporate dividing fibers

Symbols

1 Base layer

11 Base fabric

12 Pad fiber layer

13 Pad fiber layer

2 Surface layer

21 Dividing fibers

211 Petal area

212 Remaining area

22 Divided fine fibers

23 Non-dividing fibers

5 Weight adjustment area

6 Abraders

7 Measurement area

A Paper-making felt

Fig. 12 y-axis: Coefficient of friction
x-axis: Movement distance (mm)

Fig. 10 y-axis: Permeability
x-axis: Distributed ratio of dividing fibers in the dividing pad fiber layer (weight %)

Fig. 13 y-axis: Coefficient of friction
x-axis: Movement distance (mm)